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Wetlands for Remediation of Stormwater Runoff

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Frequently conflict exists between development and maintaining natural systems. A major issue of concern is how to minimize that conflict. Human development is, of necessity, intrusive into natural systems. Development plans that allow for minimal impact to the environment are considered desirable and are better if natural systems and processes can be incorporated into the development project. This may be possible in the case of road construction and maintenance and wetlands.

Typically, highway construction has resulted in a net loss of wetlands. In many cases new wetlands have been created as a by-product of road construction; but to use Indiana as an example, wetlands so created have totaled less area than wetlands destroyed by construction (Barbour and Miles 1988). However, replacement of wetlands lost with the same amount of created wetlands would not necessarily offset the environmental impact. Newly created wetlands are not mature, fully functioning wetlands (Ferlow 1993, Kentula *et al.* 1992) and only develop into functional wetlands over time. Additionally, wetlands created as by-products of road construction usually are open water ponds in abandoned borrow pits (Barbour and Miles 1988, Kentula *et al.* 1992). These are not the predominate wetlands that are destroyed.

Table 1 lists the more common wetland types that will be encountered during highway planning and construction in Indiana. The various wetland types provide different habitats and ecological functions. All wetlands are not the same. A survey of Indiana interstate highways reported by Barbour and Miles (1988) showed that open water wetlands comprised less than 25% of natural wetlands in interstate corridors. However, open water wetlands were 100% of the wetlands created as a by-product of highway construction. It seems unlikely that all wetland types were impacted in proportion to their abundance in the pre-construction landscape. Kentula

WETLAND TYPE	CHARACTERISTICS
Freshwater Marsh	dominated by soft-stemmed emergent vegetation
Riparian Forested Wetland	dominated by trees and located along waterways
Open Water Pond	minimal vegetation surrounding the wetland
Shrub - Scrub Wetland	woody shrubs form the major component of vegetation, soft-stemmed emergent vegetation will be present as may some trees

Table 1. Typical wetland types encountered by road projects in Indiana. Compiled from Barbour and Miles 1988 and Mitsch and Gosselink 1993.

et al. (1992) report that in Oregon, 23% of created wetlands were ponds while no natural ponds were impacted. Open water wetlands may be less impacted because of avoidance or being bridged. Regardless, there is a clear shift in the landscape from multiple wetland types (emergent marsh, forested, shrub-scrub, and open water) to more open water wetlands. Open water ponds may offer recreational opportunities to people, but they cannot function as an ecological substitute for the diverse array of wetlands destroyed during construction.

Highway construction impacts wetland function in many ways (Table 2). The degree of impact varies among projects and with time during a project. Direct removal only occurs during the construction phase. The other three impact categories tend to continue past construction through use and maintenance of roads. Not all impact categories will be experienced by every wetland in a highway construction zone. Some will be impacted more, some less, and some not at all. The goal is to develop plans that minimize disturbances while incorporating wetlands into final road design as a functional component. This is best accomplished by creating wetlands along the roadway to perform certain functions over the life of the roadway.

Wetlands provide many functions, both as part of the natural environment and for human use (Table 3). Hydrology, erosion control, and water quality functions may be beneficial as components in a final roadway design. These functions are best served by multiple wetland types. Different wetland types enhance ancillary benefits provided by roadside wetlands. Habitat diversity will be greater, supporting greater wildlife diversity. Aesthetic and recreational opportunities also are enhanced through wetland diversity. It is important to move away from the idea that abandoned borrow pits are all that is needed to provide wetland functions or mitigate for wetlands lost during construction. Rather than merely making wet spots, diverse created wetlands are needed to maintain landscape integrity.

TYPE of IMPACT	RESULTS
Direct Removal	complete loss of wetland functions from conversion to upland area
Increased Sediment Loading	loss of benthic aquatic habitat, change in fish and insect assemblage
Change in Hydrologic Regime	change in water depth or timing of inundation can lead to shift to different type of wetland or change in major vegetation types
Increased Loading of Salts and Chemicals	both acute and chronic increases in salts and pollutants can cause a shift in vegetation and insect community, enhanced eutrophication may result

Table 2. Major impacts to wetlands resulting from highway construction and maintenance. From Barbour and Miles 1988 and Mitsch and Gosselink 1993.

CATEGORY	FUNCTIONS and VALUES
Hydrology	flood control, low flow augmentation, groundwater recharge
Erosion Control	vegetation impedes flow, root systems bind soils
Water Quality	settling of particulate matter, chemical and biological transformation of nutrients and contaminants
Recreation / Aesthetics	fishing, boating, hunting, education, birding, photography, hiking
Wildlife Habitat	waterfowl, shorebirds, reptiles, amphibians, mammals, insects used by many rare, threatened, and endangered species
Production	plant growth and detrital production are important components in ecosystem nutrient and energy cycling

Table 3. Functions and values of wetlands. From Barbour and Miles 1988, Kentula *et al.* 1992, and Mitsch and Gosselink 1993.

One area where wetlands can be incorporated into road construction design is stormwater runoff control. During both construction and the useful life of the road, runoff from rainfall events will be greater than prior to implementation of the project. This results from a loss of vegetative cover to intercept water and impede its flow and the reduction in permeability of the surface from road building. Roadway runoff can cause increased erosion as well as carrying high levels of many contaminants. Barbour and Miles (1988) provide an appendix table that lists many of the known regulated contaminants in highway runoff. Additionally, road de-icing agents can result in increased salinity and particulates from non-regulated compounds. Designed wetlands can act as detention basins, slowing the passage of stormwater and reducing contaminant loads prior to entry into surface waterways. Wetlands can provide enhanced water quality as well as aesthetic and habitat values.

Natural wetlands reduce peak flood levels. High water levels are damped as waters are retained within the wetland basin for a period of time(Mitsch and Gosselink 1993) and, while runoff is held, chemical and biological transformations occur within the wetland to reduce contaminant levels. Emergent wetlands offer the greatest flow damping capacity as dense vegetation slows water flows. Created wetlands have been studied as a mechanism for runoff control and been found to be effective. Higgins *et al.* (1993) discuss the control of agricultural runoff in Maine with created wetlands. Ferlow (1993) reports on the use of wetlands as biofilters in urban areas to retain urban stormwater runoff. He suggests shrub-scrub or emergent wetlands

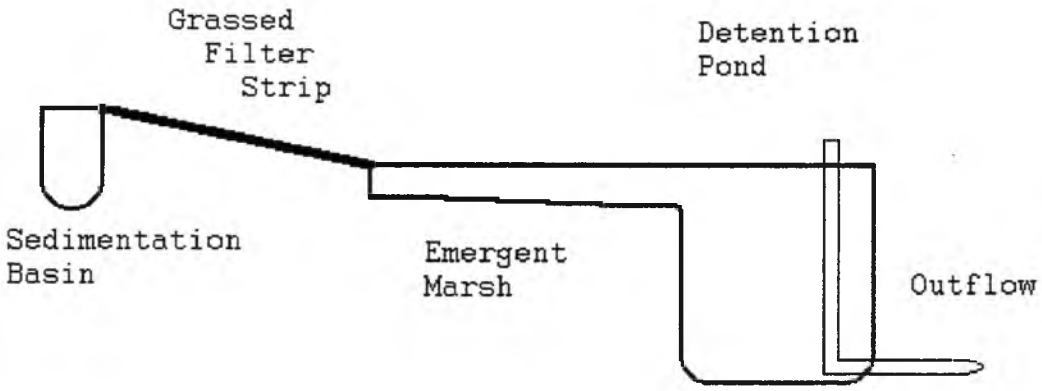

Figure 1. Schematic representation of created wetland to control agricultural runoff. Adapted from Higgins et al. (1993).

for this use. The principles are the same in each case and there is no reason that the technology can not be extended to ameliorate roadway stormwater runoff. Two direct benefits are obtained and resulting in enhanced water quality in surface waterways that ultimately receive inputs from stormwater runoff.

One design for agricultural runoff control (Higgins *et al.* 1993) incorporates an initial sedimentation basin, grassed filter strip, emergent marsh wetland, and final detention pond along its length (Figure 1). A design for urban runoff control (Ferlow 1993) has runoff entering through a shrub-covered zone, passing through a deep pool surrounded by an emergent marsh, flowing across a wet meadow through another shrub zone and into waterways (Figure 2). Each system is designed to be dynamic, support a diverse community, and function as part of the ecological landscape. Integrated designs such as these provide ancillary benefits beyond the immediate water quality aspects. They may be aesthetically appealing while providing divers habitats for vegetation and animals.

Roadway wetlands that are diverse and reflect the typical make-up of wetlands in the area where they are created appeal to most environmental groups. Total landscape impact is lessened

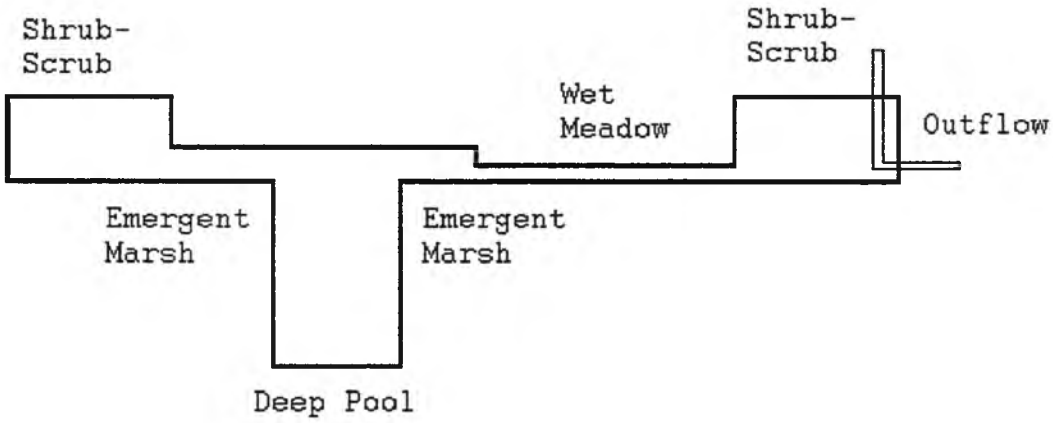

Figure 2. Schematic representation of urban biofilter system. Adapted from Ferlow (1993).

because the degree of change is smaller. Different wetlands provide a more diverse range of habitats and serve a greater range of wild animals and plants. This is not to say that highway projects must make approval from environmental groups a top priority, but that plans should include this level of consideration. In most instances, it is dictated by policy that they must.

How should wetlands be incorporated into road construction projects? The first step is to determine the representative distribution of wetlands in the landscape through which the road will pass. Wetlands should be created in such a manner that this distribution is maintained. Examine the topography of the area. Determine suitable places for wetland creation that will maximize the benefits needed. Design created wetlands to work with the landscape. This minimizes earthmoving and construction costs. Utilize existing flow patterns in the design. Obviously, it does little good to site runoff control wetlands in areas that generate little runoff following storms or snowmelt. Areas with highly permeable sandy soils are unsuitable for wetland creation. The additional expense of providing a suitably impermeable substrate to retain water makes such ventures economically unfeasible. Avoid using steep-sloped sides. This retards vegetation establishment (Kentula *et al.* 1992). Gentle slopes allow vegetation to establish and develop zones around the periphery of the wetland. This further increases habitat diversity. Determine if supplemental planting will be necessary. For wetlands receiving large periodic stormwater events, supplemental planting may be necessary to establish vegetation quickly to prevent erosion. This is costly (Kentula *et al.* 1992). If erosion is not a concern, natural vegetation establishment may be sufficient. Studies in Oregon and Florida found that the majority of the vegetation in created wetlands was from species that naturally invaded after the initial planting (Kentula *et al.* 1992).

If planting is necessary, use field surveys of naturally occurring wetlands in the surrounding area of the type to be created to determine a representative floristic composition. Botanists familiar with the region may be able to provide this information. A planting guide, such as *Wetland Planting Guide for the Northeastern United States* by Thunhorst (1993), may offer useful information. However, planting guides must contain information about wetland types in which particular plants occur to be useful. A listing of the geographic range of a particular plant will not tell you if it occurs in wet meadows as opposed to bogs or forested wetlands. A complete description of the habits and habitats of plants is needed.. A field check should always be done to verify that selected plants do occur in that wetland type in that area. Conduct planting as early in the season as possible for best establishment during the first year. Even with planted wetlands, establishment of plants through natural colonization should not be discouraged, unless these plants are noxious invaders.

Highway projects and wetlands are not necessarily mutually exclusive. Thoughtful design can minimize the impacts of roads and road construction on wetlands. It is important to keep wetland diversity a part of highway designs. Created wetlands, designed into projects, provide the functions of natural wetlands and can be used to provide additional benefits related to flooding and water quality.

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